self-study

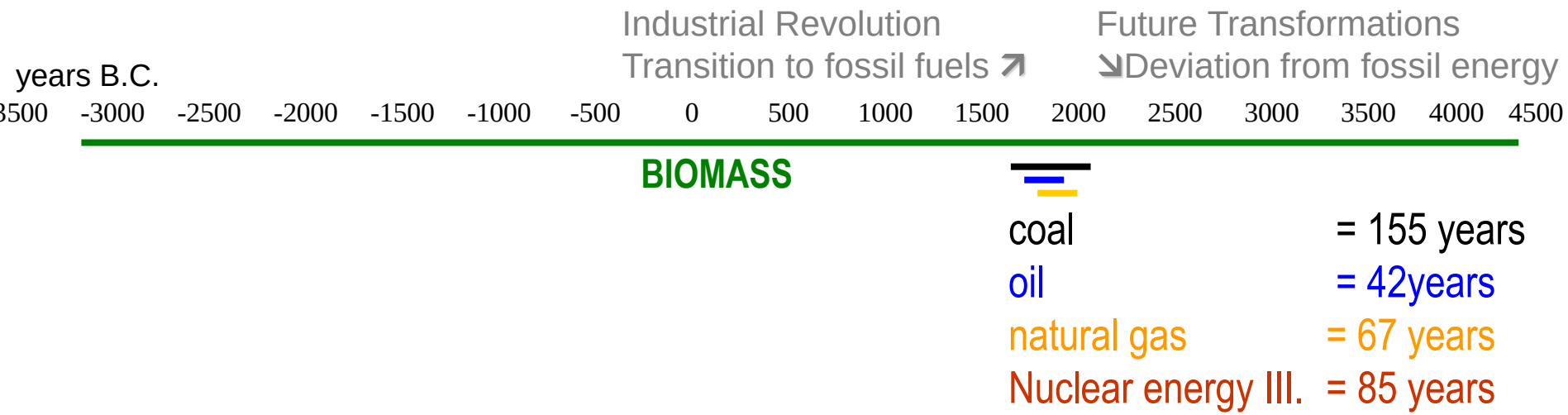
Biomass

- energy recovery
- types of biomass

Biomass

traditional source

- the basic energy source in the past
- biomass energy potential - 10 times exceeds the energy needs



Biomass

local source - available in the given location

- cultivation promotes local employment
- utilization supports the local economy
- development of regions
- resource decentralization, energy self-sufficiency

Biomass – by type:

- of animal origin
- of plant origin – <u>fytomass</u>

▪ Biomass – of animal origin:

excrements – agricultural production,

stable animals

waste – landfilling,

sewage from

water treatment plant

Biomass – of plant origin – fytomass

fire wood,

chips,

pellets,

briquettes

lecture deals only fytomass

Biomass – of plant origin – fytomass

straw bundles

grass bundles

agro-pellets

Biomass – of plant origin – fytomass

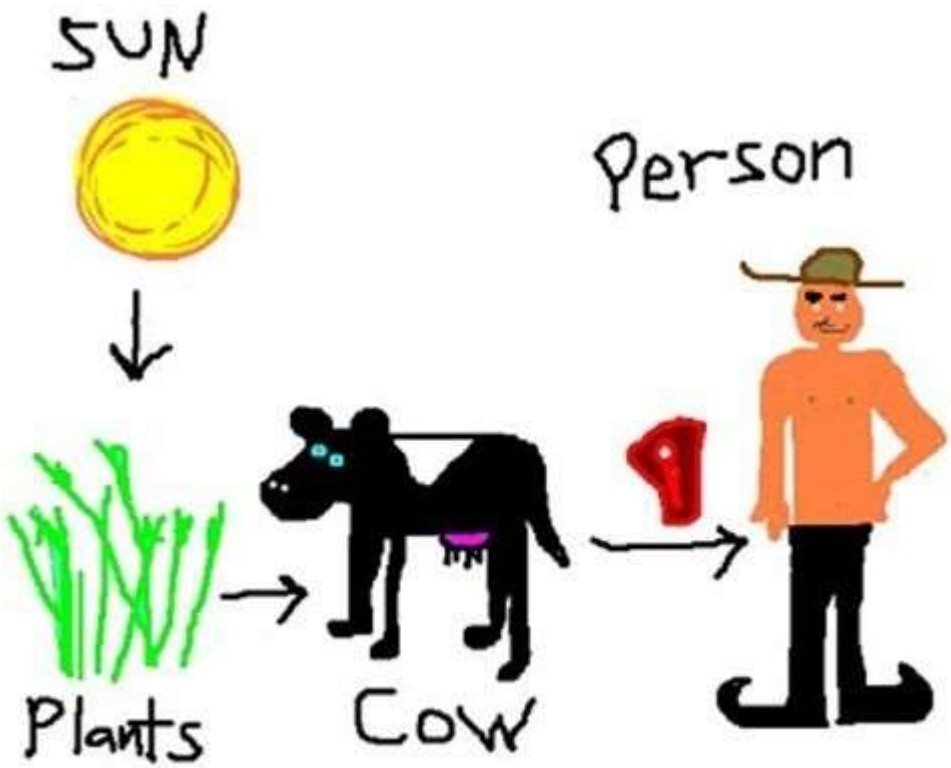
energy plants – targeted cultivars

cereals and grasses (parcels)

crops - oil (seeds), sugars (fruits, sugar beet, etc.), starches (corn, potatoes, etc.)

Biomass – fytomass

Fytomass (**plants**) is the basis of all produced biomass (food chain)



Energy biomass - "energy generation"

- **energy aspects**
  - replacement of fossil fuels
  - reduction of fuel imports
  - increasing domestic fuel reserves

Energy biomass - "energy generation"

- **social aspects**
  - non-food production of land (arable + meadows) not used for food, does not compete on food market = **use of surplus land**
  - local energy
  - local employment
  - local economy

Energy biomass - "energy generation"

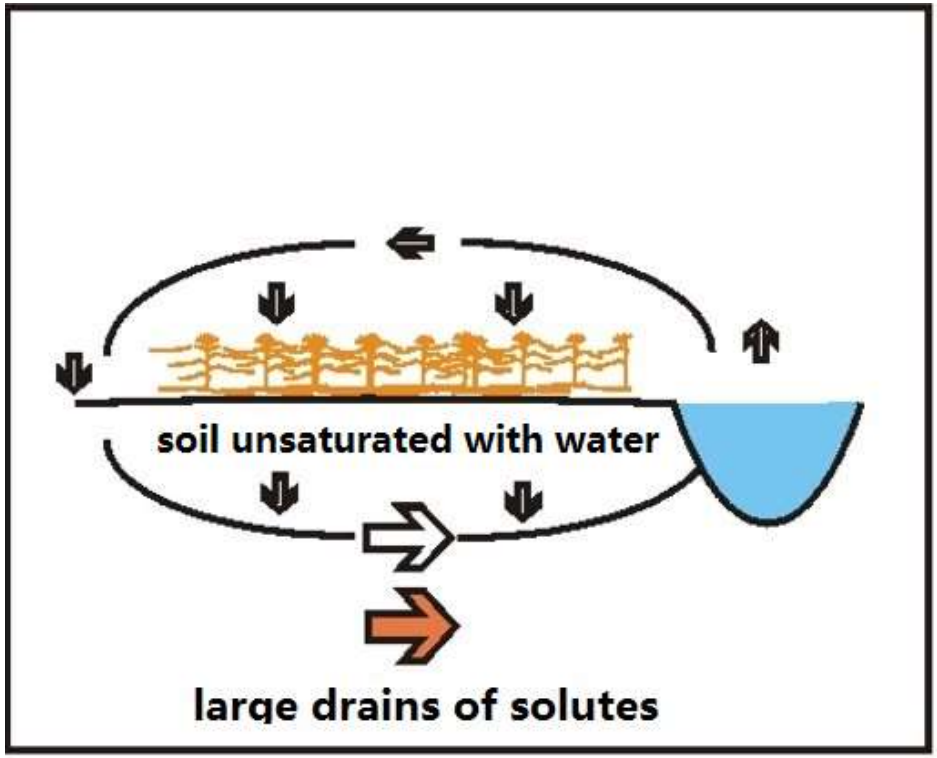
- **ecological aspects**
  - intensive vegetation
  - CO_2 from the air is used for photosynthesis
  - consistent and efficient cultivation of land, landscaping, landscape care

Energy biomass - "energy generation"

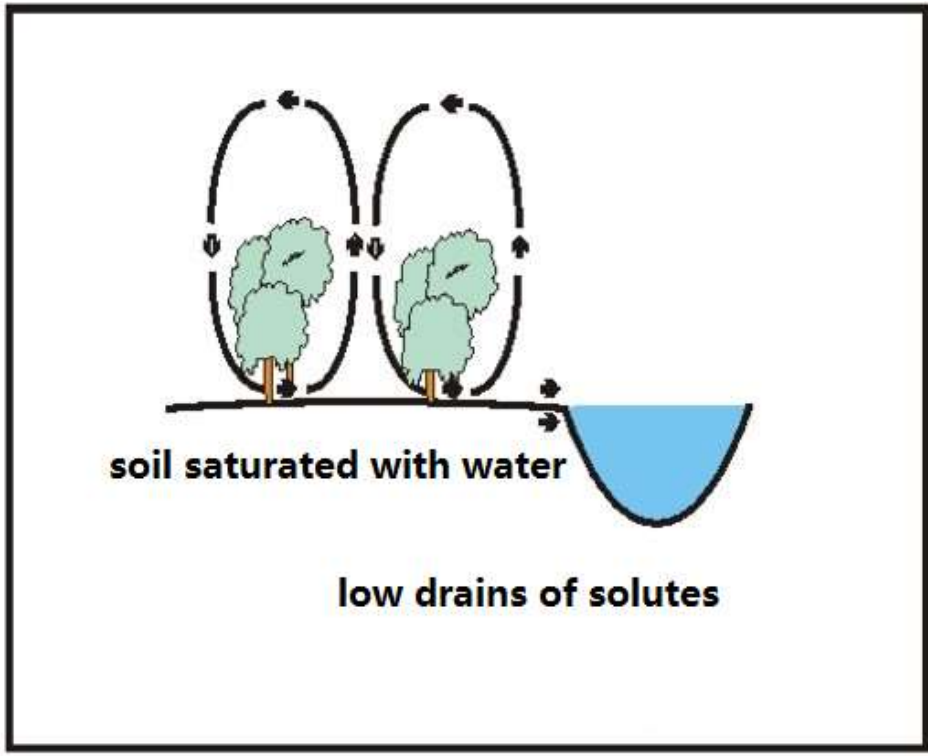
- **ecological aspects**

anti-erosion measures, water retention in the landscape

NO



YES



Energy biomass - "energy generation"

- **ecological aspects**
  - new species, species diversity, stability of ecosystems
  - waste disposal, the efficient management of agricultural waste and surpluses

Energy use of biomass

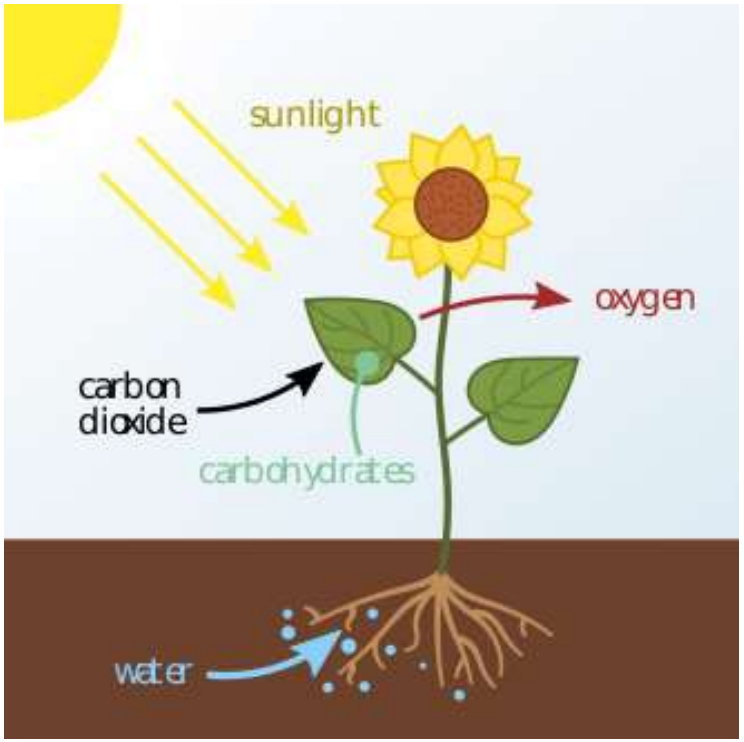
Fuel from biomass (biofuels)

- **solid fuels**
  - wood fuel, wood chips, pellets, briquettes, bark, sawdust
- **(liquid fuels)**
  - bioethanol, biomethane
  - vegetable oils
  - pyrolysis oils
- **(gaseous fuels)**
  - biogas (CH_4+CO_2)
  - wood gas (CO+CH_4)
  - synthesis gas (CO+ CH_4 + CO_2 + H_2)

Car Running on Wood Chips during WW2

Photosynthesis

Use solar radiation, synthesis of organic compounds from carbon dioxide CO_2, and water H_2O (+ chlorophyll as photosynthesis catalyst)



Organic compounds = chemical energy stored in carbohydrate molecules such as sugars.

Oxygen is also released as a waste product.

$$CO_2 + 6\,H_2O + \text{solar energy} = C_6H_{12}O_6 + 6\,O_2$$

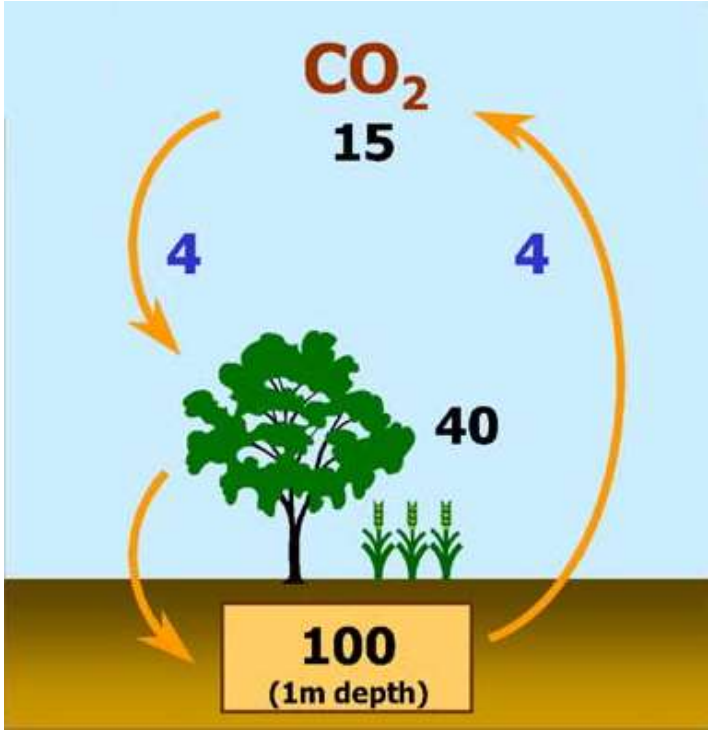
(+ trace elements from the soil)

fytomass = renewable fuel,

accumulated solar energy

carbon cycle of phytomass

During the formation of the phytomass the carbon is removed from the atmosphere and deposited in the organic material



in units of Mg C /ha (/hectare)

fytomass = CO_2 neutral

(agreement: emission factor CO_2 = 0)

Monitor also CO, C_xH_y, dust, NO_x emissions !

Phytomass fuel – wood substance

- **logs wood**
  - cutting, splitting
  - residual biomass
  - use in households
  - low price
  - high storage space requirements
  - low proportion of automation
  - **boiler with manual attachment**

Phytomass fuel – wood substance

- **Chips** size 1 to 10 cm
- **Green chips**
  - fresh wood from forest extraction (needles, leaves)
  - for **power plants**, wood burning plant
- **Brown chips**
  - old wood: more bark, without needles
  - low humidity, good storage
- **White chips**
  - debarked wood, sawmills, plates production

automatic boilers (loose fuel)

Extraction and processing of wood biomass

- **Wood logging**
  - 70% will be used for further processing
  - 30% of mining is **waste** (mining residues)
  - another 25% is **waste from wood processing**

Mining residues processing

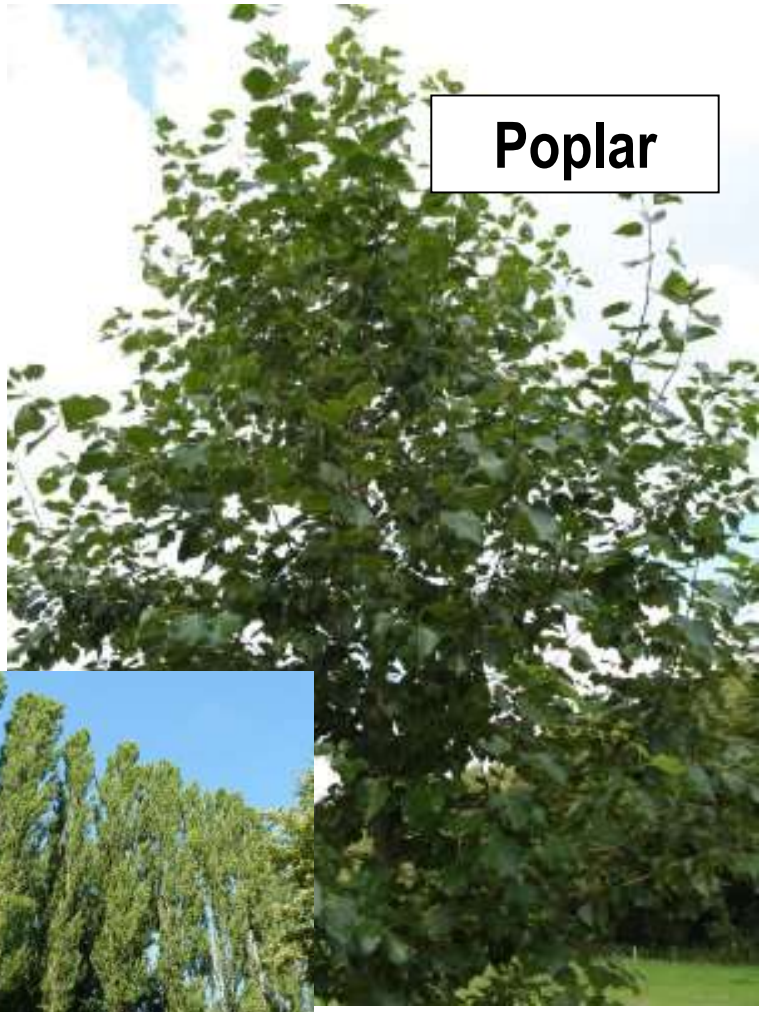
- **mining residues** (small branches…)
  - Source of nutrients for the soil. The protectors warn of "clearing" the forest
  - soil polluted biomass
  - Crushers … for contaminated biomass
  - Chippers … for clean biomass

Mining residues processing

Crushers

Energy forestry

- **fast growing trees**
  - varieties of Poplar, Willow,..
  - Production plantation, 3-6 years
  - repeated harvest
  - **chips for automatic boilers**
- **reasons**
  - sources of waste biomass are limited
  - there is no biomass market - local character
  - **target: 50-60% biomass targeted cultivation**



Energy forestry

Straw

- **Straw (dried stalks of grain)**
  - low density
  - pressed packages
  - high content of volatile (80%)
  - high content of chlorine (fertilizers,..)
  - high ash content
  - low softening point and melting point
  - **special straw boilers**

Grasses

- **grasses, fast growing plants**
  - annual: industrial Canabis

  - multi-year: no need to plant stands, seed savings
    sorrel(Rumex OK2) endurance of stands,
    height 1.8 - 2.5 m, yield 10 t / ha

  - **for pellets and briquettes**
  - **automatic or manual boilers**
  - **combustion in large appliances**

Standardized fuels - briquettes

- **wooden briquettes**
  - high quality wood waste - sawdust, shavings
  - high pressure compression
  - high calorific value min. 16.5 MJ / kg
  - size 4 - 10 cm, length 30 cm

- **agro briquettes**
  - more accessible materiál
  - stalks, straw, oilseed rape
  - contains a lot of ash
  - calorific value from 12 to 17 MJ / kg

for boilers with manual insertion

Standardized fuels - pellets

- **White pellets (wooden)**
  - quality clean wood waste – sawdust
  - high pressure compression
  - diameter 6 to 8 mm, length up to 50 mm
  - high calorific value min. 16.5 MJ / kg

  - **agropelets (brown, alternative)**
  - hay, rapeseed straw,
  - can not be burned in the same boilers as white pellets - high ash content
  - calorific value 15.4 MJ / kg

for automatic boilers (bulk fuel)
small and large sources

Chemical composition of biomass

druh	C	H	O	N	S	Cl
wood	50	6,2	43	0,1	0,02	0,01
straw	49	6,3	43	0,5	0,1	0,4
cereal grain	46	6,6	45	2,0	0,1	0,1
hay (grass)	49	6,3	43	1,4	0,2	0,8
brown coal	68,9	6,0	23	1,0	1,0	0,03

Fytomass has a high oxygen (O) content.
This is at the expense of carbon (C) content.
That's why fytomass has lower calorific value than other fuels.

content of volatile flammability: wood ……. 75 %

straw, grass… 80 - 85%

Ash content (inorganic substances)

- **biomass**
  - straw, grass: 3 - 5%
  - bark: up to 6%
  - wood mass: <2%
  - wood pellets: <1%
  - plant pellets: up to 5%
- **it also depends on the method:**
  - cultivation
  - storage

black coal 10 - 15%

brown coal 10 - 30%

coal briquettes 10 - 40%

Ash content (inorganic substances)

- **ash melting temperature**
  - So high in most phytomass species 1100 to 1200 °C
  - straw, grass 800 to 900 °C
- **If: melting temperature < flame temperature**
  - melting ash
  - sealing the grate and baking
  - it is necessary to combine two fuels - low melting ash + high melting ash
  - special boilers

Humidity

- **definitions for energy use**

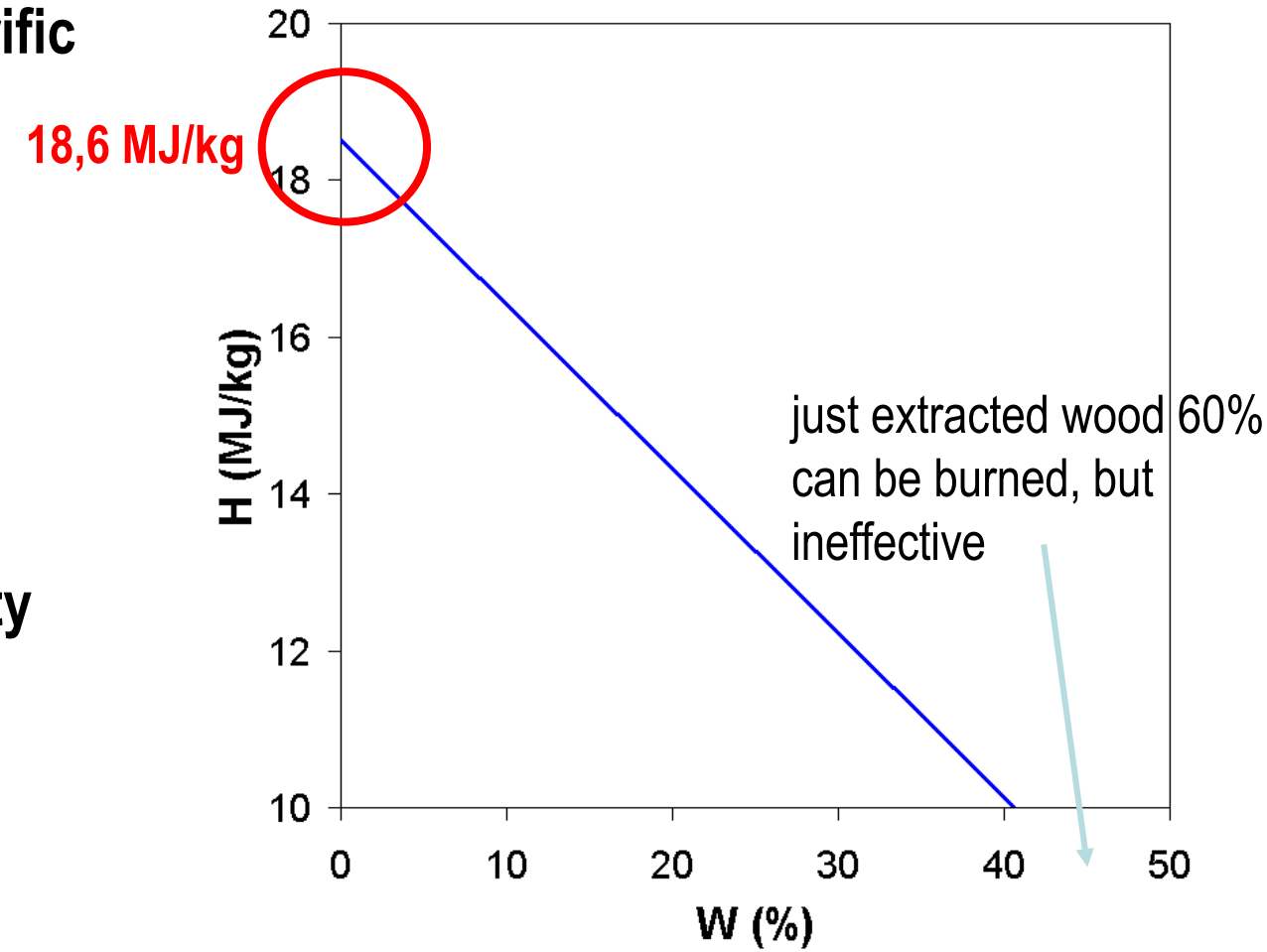
$$W = \frac{\text{weight of water in the sample}}{\text{original sample weight}}$$

- **typical values**
  - fresh wood 40 to 60%
  - green plants: up to 80%
  - wood after 1 - 2 years drying out: 15 to 20%
  - pellets, briquettes: <10%

depends on the method and length of storage

Humidity

- **influence on calorific value H**
  - effectiveness
  - Power
  - fuel consumption
- **combustion quality**
  - emission
  - boiler lifetime



$$H = \frac{18{,}6 \cdot (100 - W) - 2{,}453 \cdot W}{100} \quad [\text{MJ/kg}]$$

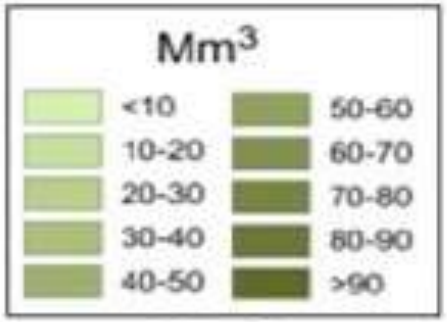
Energy content in biomass

- **calorific value** (LHV)
  - the amount of heat you get by burning (oxidizing) 1 kg of wood
  - is measured calorimetrically

- **combustion heat** (HHV)
  - higher on the heat of the water
  - the difference can be released by condensation from flue gas

Average estimates of forest wood biomass potentials in Europe.

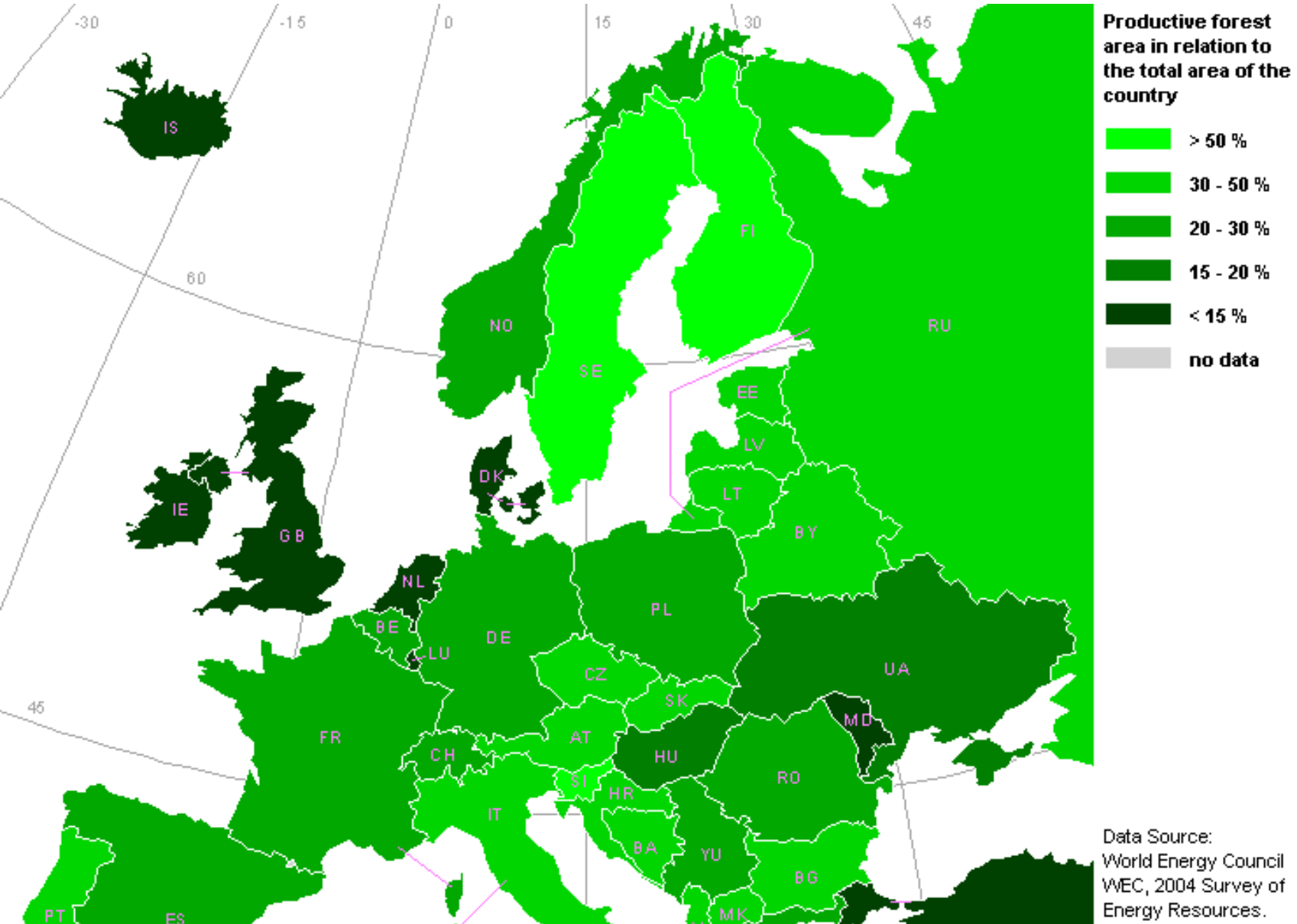
Above ground biomass, current conditions.



Total biomass, highest potential

Total biomass, current conditions

Source: University of Eastern Finland et all. 2012



Data Source:
World Energy Council
WEC, 2004 Survey of Energy Resources.